BULLETIN No. 16. Agros. 32.

U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF AGROSTOLOGY.
[Grass and Forage Plant Investigations.]

GRAZING PROBLEMS IN THE SOUTHWEST AND HOW TO MEET THEM.

BY

JARED G. SMITH,
ASSISTANT AGROSTOLOGIST.

PREPARED UNDER THE DIRECTION OF THE AGROSTOLOGIST.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF AGROSTOLOGY,
Washington, D. C., January 25, 1899.

SIR: I have the honor to transmit herewith, and to recommend for publication as Bulletin No. 16 of this Division, a report on the grazing problems in the Southwest and how to meet them, by Jared G. Smith, assistant chief of this Division.

Respectfully,

F. LAMSON-SCRIBNER,
Agrostologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

The vast areas of grazing lands in the Southwest have long been justly famous, and the almost numberless herds of cattle and bands of horses raised and fattened upon the nutritious grasses of that region have enriched thousands of individuals and have been a source of great commercial wealth to the nation.

Less than thirty years ago 4,000,000 buffaloes and countless numbers of wild horses roamed unrestricted over the region in question, gradually moving northward as the season advanced, returning southward at the approach of winter. This natural movement of the stock permitted alternation of pasturing and rest for the land, resulting in the maintenance of the forage supply; in fact it was an ideal method of fostering and improving these pasture lands which covered nearly 200,000 square miles of country.

The nature and extent of the interests here, make this region an especially important one in the line of grass and forage plant investigation. The carrying capacity has diminished fully 40 per cent through overstocking and bad management during the past fifteen years, and the grazing and forage problems of the region demand serious and careful attention.

The Secretary of Agriculture, fully appreciating these conditions, directed this Division early in 1897 to begin investigations of these forage problems and conditions throughout the region of the Southwest, with instructions that particular attention be given to the native grasses and forage plants, their abundance and value, their preservation, and the possible methods to be employed in restoring the former carrying capacity of the ranges. The Division was also empowered to establish experiment stations for testing the grasses and forage plants in different sections of this region and to practice such methods of range renewal as might seem worthy of trial.

As a preliminary to these investigations a circular of inquiry was sent out to over 1,500 stockmen in Texas, New Mexico, etc. The replies, together with other correspondence which these circulars elicited, have brought together many valuable facts and demonstrated that the stockmen throughout the region in question are anxious that the work should be commenced and willing to cooperate with the Department in any way possible.

The assistant chief of the Division was sent to Texas about the middle of May, 1897, and between that time and the 1st of September collected botanical material and made extensive notes and observations on range conditions of central and southern Texas, visiting some 30 stations in that State and New Mexico, securing information by direct

observation in about 50 counties, and getting a great many notes from stockmen in regard to the grasses and topography of the country and the natural conditions of sections which it was impossible to explore. The work was carried up the Pecos Valley as far as Roswell and to Deming and Silver City in western New Mexico.

Mr. H. L. Bentley, of Abilene, was given a commission to collect specimens, make notes and write a report on the past and present conditions of the grazing industry in central Texas. His report, applicable to the territory, 200 miles long and 150 miles wide, between the ninety-eighth meridian and the western edge of the Staked Plains, has been published by this Division, in Farmers' Bulletin No. 72 and Divisional Bulletin No. 10. Mr. Orrick Metcalfe was employed to collect seeds of the best of the range grasses in the vicinity of Silver City and along the valley of the Gila.

As a result of this work it was decided to obtain control of a body of overgrazed land in the Panhandle and another in central Texas in order to carry on experiments in methods of practical range improvement. After correspondence with a number of the leading stockmen Prof. C. C. Georgeson was sent in March, 1898, to inspect the sections offered for the use of this Division. He chose 640 acres near Channing, on the north plain, north of the Canadian River, and another 640 acres near Abilene, just south of the western arm of the western cross timber belt. Professor Georgeson organized and commenced experiments at Channing, but was unable to establish the work at Abilene because of a transfer to another line of work in the Department, and Mr. Smith was ordered to Abilene to superintend the matter during the latter part of March and first of April. In order to carry on the work as outlined Mr. H. L. Bentley, of Abilene, Tex., was given a commission as special agent in charge of the experiments at that point.

This work in range improvement is the first that has been tried either by the Government or by any State experiment station. The only experiment at all comparable was that begun some years ago at Garden City, Kans.

Some preliminary work had been done in the Southwest by this Division in 1896. In February of that year Mr. C. R. Orcutt, of San Diego, Cal., was given a commission for three months. He was instructed to proceed through Arizona and New Mexico as far east as El Paso, and to collect such specimens and make such general observations concerning the grasses and forage plants of the region as would be of interest to the Division. In September, 1896, the assistant chief of the Division was instructed to proceed to several points in Texas and New Mexico for the purpose of acquiring information concerning the grasses and forage plants of that region. In consequence of this trip we have been able to secure, through Mr. James K. Metcalfe, of Silver City, N. Mex., quantities of seeds of native grasses and forage plants, which have been used in the experimental work of the Division.

It will be of interest to many to note here the work previously done by the Department of Agriculture in the Southwest.

In 1886 Dr. George Vasey, in Bulletin No. 1 of the Division of Botany, drew attention to the enormous loss of cattle in the Southwest through overstocking of the ranges and lack of protection from storms in winter. In 1883–84 the Bureau of Animal Industry investigated the range problems with special reference to the loss of stock from storms. This loss was estimated to vary from 5 per cent in a mild winter in Texas to 18 or 20 per cent in the Dakotas and Montana. The next report which treated of the condition of affairs in Texas was Bulletin No. 3 of the Division of Botany, published in 1887, in which the attention of the general public was for the first time drawn to the value in cultivation of Colorado grass (*Panicum texanum*) and Texas blue grass (*Poa arachnifera*), and also to alfilaree, bur clover, Japan clover, mesquite bean, and prickly pear. In 1887 an expedition was conducted in western Texas by Mr. G. C. Nealley, and in New Mexico, Arizona, Nevada, and Utah by Prof. S. M. Tracy, who was at that time at the University of Missouri. Professor Tracy's report was largely botanical, while Mr. Nealley's was not only botanical, but contained many economic notes in regard to the grasses and such forage plants as "sotol," mesquite bean, and prickly pear. The reports of Messrs. Tracy and Nealley were published in Bulletin No. 6 of the Division of Botany. An enumeration of the grasses of Texas, with descriptions by Mr. L. H. Dewey, assistant botanist, was published in Vol. II of the Contributions to the National Herbarium in 1890.

In 1891 Dr. Vasey, accompanied by Mr. L. H. Dewey, made a trip along the line of the Southern Pacific Railroad in Texas, New Mexico, and Arizona, stopping en route to make botanical collections and secure notes. These, however, were never published. Considerable collecting was done in 1890–91 by G. C. Nealley, mainly in the territory along the line of the Mexican National, the International, and the Southern Pacific railroads. In 1891 Mr. F. V. Coville, Chief of the Division of Botany, and Frederick Funston investigated from a botanical standpoint the flora of southwestern Nevada and southeastern California, incidentally gathering notes concerning the forage value of many of the plants of that region.

Previous to 1888 there were a dozen or more expeditions through some parts of the Southwest, but the notes made were almost solely in regard to the botanical relationship of the different plants. We are indebted for much of our knowledge of the forage plants other than grasses to the work of Drs. Palmer and Havard, the latter having been stationed at different army posts in Texas and the Southwest for a number of years. Dr. Havard's most valuable contribution was published as "A report on the flora of southern and western Texas" in Vol. VIII of the Proceedings of the United States National Museum, 1885.

F. L.-S.

CONTENTS.

ILLUSTRATIONS.

GRAZING PROBLEMS IN THE SOUTHWEST AND HOW TO MEET THEM.

INTRODUCTION.

The plains and prairies of Texas have long been famed as grazing regions. There are few similar areas where the natural conditions at the time of first occupation were so favorable to the rapid development of the stock industry. The country lying between the Rio Grande and the thirty-fifth parallel of latitude and between the ninety-eighth and one hundred and fifth meridians is a succession of prairies and plains, rising gradually by successive broad steps from the coast to the table-land of the Staked Plains at an altitude of about 4,000 feet. This series of plains is broken by mountains only in the southern and southwestern portion and west of the Pecos River beyond their borders. Of the 190,000 square miles embraced in this territory probably not more than 10 per cent is adapted to successful agriculture under present methods, although one-fifth or one-third of it is capable of conversion into farm lands, and doubtless will be so converted at some future period, when the farmer is able to preserve the abundant natural resources of the region and profit thereby.

At the time of the earliest settlement this Texas territory was for the most part treeless, excepting along the streams and where the two bodies of "cross timbers" entered it on the north and where a wedge-shaped tongue of the east Texan timber belt penetrates the prairies south of Austin and San Antonio. The land was well covered with grasses, and was grazed by immense herds of buffalo, wild horses, and great numbers of deer and antelope.

Among stockmen the tendency has been to look upon these wild lands as never having been grazed until cattle and sheep were introduced, but there is abundant evidence to show that they have always been closely pastured. The early explorers differed in their accounts of the luxuriance of the grass vegetation, but the differences were no greater than can be accounted for by local or temporary causes, such as variable seasonal rainfall, which occur at the present day.

It is estimated that the southern buffalo herd contained not less than four million head.* This vast number grazed in the district south of the Platte River, retiring to the plains of western Texas and the Indian Territory at the approach of winter, and turning northward again in

* Smithson. Report National Museum, 1887. The Extermination of the American Bison, p. 498 and following. Hornaday.

early spring. There were also numberless herds of wild horses, according to the narratives of some of the early explorers and hunters.

There was a constant shifting of the wild herds in their search for the best pasturage, and with the season, drifting northward with the spring and southward at the approach of winter, congregating where there was water and grass. The conditions were entirely natural and the movements of the herds were almost unrestricted. The intermittent grazing and resting of the land resulting from the roving habits of the buffalo and mustangs was an ideal method of fostering and improving the natural pasturage. The result of this alternation of pastures, conducted on a gigantic scale, was that the native grasses were allowed to fully ripen their seeds, and perpetuate themselves each year in the most liberal manner. The best grazing grasses were developed by the processes of natural selection and survival of the fittest. Weeds and brush were kept in check by the annual fires set by the Indians in early spring to improve the pasturage for their ponies and the wild game. In this manner the encroachment of thorny shrubs, cactus, and mesquite was prevented, and each grew only where protected in the valleys along the streams or in scattered clumps at rare intervals in the open. The disappearance of the buffalo* was nearly coincident with that of the Indian,† and there was a period of fully ten years after the destruction of the buffalo herds before the number of cattle and sheep on any portion of the ranges equaled the great herds of game. These years, from 1874 to 1884, may be called the "golden period" of the Southwestern stockman, or at least a golden one for those whose flocks and herds were already on the ranges. During this intermediate decade there were fewer head of stock, wild or domestic, than at any previous period. There were also abundant rains and the seasons were mild and favorable to the full development of the grasses. Grasses and forage plants, ungrazed, grew and thrived, reseeded themselves, and increased to a wonderful degree of luxuriance, so that the stockmen on entering this pastoral paradise thought that it was not possible to put enough cattle and sheep on the land to eat down all of the rank growth of vegetation. It is the common testimony of the older stockmen that in the early eighties the grass was often as high as a cow's back, not only along the river bottoms, but also on the uplands far from the creeks and rivers.‡

FREE RANGES.

Before 1883 the ranges of central and western Texas were free to any man who chose to run stock upon them. The land was inaccessible from the railroads and was considered of no value for general farming

* The Southern buffalo herd was almost exterminated in 1873. Hornaday, l. c.

† The last Indian tribes were removed from Texas by act of Congress in 1874. Bancroft's Works, Vol. XVI, p. 25, 1889.

‡ Farmers' Bul. No. 72, Cattle Ranges of the Southwest.

purposes. In 1883 the Texas and Pacific Railroad was built through the heart of the range country, and there was an influx both of owners or agents of the lands and of investors who were seeking to acquire free ranges and free grass. Toward the close of this ten-years' shortage of stock there were undoubtedly sections where the native grasses would support 300 head of stock per square mile; and the average carrying capacity of the ranges as a whole was, so far as known, higher than at any time before or since. With the building of the railroad the stock industry underwent a very rapid development. Newcomers who had not seen the land when it was possessed by the Indian, the buffalo and mustang, at the time when the herbage was eaten down, or kept in check by fires or drought, naturally thought that this rich profusion of vegetation was the normal condition and that the saying that it was impossible to put enough cows on the land to eat all the grass was literally true. The result was a rapid and exhausting overstocking of every available square mile of range land. The best grasses were eaten down to their very roots, the roots were trampled into the earth, and every green thing was cut down so that it could neither ripen seed, and thus perpetuate its kind, nor recover from the trampling and exposure of its roots to the air and sun. The recuperative power of the grasses was lessened or destroyed, and weedy species which were present before, but which had been held in check by the luxuriance of the better, dominant sorts, immediately increased in number by rapid bounds. So also the mesquite bean and the cactus, both of which may be destroyed by fire, grew in numbers and commenced to crowd out the grasses.

OVERSTOCKING THE RANGE.

There are many square miles of territory in the Southwest where the ruthless destruction of grass has been carried to the extent mentioned above. The grazing capacity of large bodies of land has been reduced within a period of twenty years from one head to 2 to 5 acres, to one head to 20 or 25 acres. As late as 1883 from 128 to 320 head of cattle could be supported on a single section, where to support a like number now requires from 4 to 12 square miles. Where the conditions have been especially unfavorable, stockmen report that it sometimes requires 60 acres per head, and the land there is almost bare of vegetation. Such denuded areas occur in New Mexico and Arizona, and are due almost entirely to the ruthless destruction of free grass on public lands.

The chief cause of overstocking in the first place was the free-range system, under which lands owned by the State, public institutions, or corporations, under the common law and in the absence of the owners or their agents, were considered as commons upon which any man was free to pasture all the cattle or sheep which he could command. The holding or use of lands in common always results in rapine, because of the principle that what is everyone's property is no one's, and no one is responsible for its abuse and spoliation. Because the legal owners

of the land—in this case largely the State and public institutions and railroads—were not on hand to maintain their rights, they were ignored, and the result was then as it is now in most of the Western States and Territories containing unalienated Government land, that every blade of free grass was stripped from the soil. No thought was given to preserving the inheritance of those who were to occupy the land in future years; it was every man for himself, and he was the best man who could put the most cattle on the ranges to eat the most of the free grass. The natural outcome of this was that the ranges throughout the entire region were overstocked. Cow men thought that they could not put enough cattle on the ranges to eat all the free grass, and it was a very great surprise to most of them when in 1884 they began to discover the fallacy of this idea. The losses at that time throughout the whole Southwest were enormous, and the only thought of those who continued in the cattle business during the succeeding years was to recoup at all hazards and to follow the same tactics that had been previously employed—putting upon the pasture every head of stock which it was believed the land would sustain. As the strength of any structure is equal to the strength of its weakest part, so the carrying capacity of any large area may be considered equal to the number of stock which may be supported upon it during its poorest years. Just so sure as the number of grazing animals is allowed to increase beyond this conservative estimate there enters a greater liability to loss. For example, it is never safe to attempt to graze 75 or 80 head upon a section of land which will only safely carry 50 head the year round, although if the natural conditions are exceptionally favorable during a particular year a man may overstock his pastures and realize a profit during that year. On the contrary, should the natural conditions not prove to be as favorable as the stockman had hoped, his losses at 75 or 80 head per square mile will largely exceed the normal losses were the land stocked only to the extent of its minimum carrying capacity. Not only will the pecuniary loss, or the liability to such loss, be less and the actual profits on the cattle be more in the case of undergrazing, but the land itself will gradually increase in value and the grazing capacity will be augmented from year to year. In one case the land is stocked beyond its carrying capacity, so that it rapidly and continuously deteriorates in value; in the other case there is a constant increase in value both of the land and its products during the same series of years.

INVESTIGATION OF GRAZING PROBLEMS.

In the prosecution of an investigation of the Texas ranges a number of circular letters were sent by the chief of the division to cattle and sheep owners in the Southwest asking for estimates as to the percentage of increase or decrease of the carrying capacity of the ranges. An inquiry was also made as to what, in the opinion of stockmen, were

the chief forage problems of this section; and advice was asked as to methods of restoring, renewing, and improving the ranges where they had been overgrazed. About 300 replies were received from stock and range owners in the State of Texas, and some of the data furnished are here tabulated:

County.	Number of persons reporting.	The present carrying capacity of the ranges; number of head per square mile.			Estimated percentage of increase or decrease in carrying capacity of the range in a period of twenty-five years.		
		Cattle.	Horses.	Sheep.	Decrease (per cent).	Neither decrease nor increase.	Increase (per cent).
Aransas	1	80	50	.....	40	.....	.....
Archer	3	40	.....	300 to 700	38	.....	.....
Armstrong	1	35	.....	.....	.....	.....	.....
Atascosa	1	53	40	.....	25	.....	.....
Bexar	5	66	50	.....	40	(a)	.....
Brazoria—							
Average	7	96	90	.....	40	(a)	.....
Salt grass	1	128	.....	.....	.....	.....	.....
Prairie	2	130	.....	.....	.....	.....	.....
Wooded bottoms	2	32	.....	.....	.....	(a)	.....
Brewster	1	45	.....	.....	.....	.....	.....
Brown	1	40	.....	.....	8	.....	.....
Burnet	1	.....	.....	.....	.....	(a)	.....
Castro	2	45	40	.....	25	(a)	.....
Calhoun	1	213	.....	.....	.....	.....	.....
Callahan	2	60	35	300	b 40	.....	.....
Camp	1	10	.....	.....	b 90	.....	.....
Carson	2	65	.....	.....	.....	.....	.....
Childress	4	58	45	.....	35	(a)	.....
Clay (average)	10	84	.....	.....	25	.....	.....
Coke	1	50	30	.....	.....	(a)	.....
Collin	2	150	.....	1,000	10	.....	.....
Collin	1	c 250	.....	.....	33	.....	.....
Coleman	3	70	.....	300	.....	(a)	(d)
Collingsworth	1	64	40	.....	.....	(a)	.....
Colorado	1	75	.....	.....	50	.....	.....
Comal	1	60	30	200	50	.....	.....
Comanche	1	60	40	.....	50	.....	.....
Concho	1	50	.....	.....	e 5 to 17	.....	.....
Cooke	3	80	20	100	38	.....	.....
Crockett	1	25	20	100	.....	.....	(d)
Crosby	1	40	30	100	38	.....	.....
Dallas (average)	4	77	85	210	27	(a)	.....
Deaf Smith	3	32	.....	.....	.....	.....	20 to 25
Denton	1	83	.....	.....	33	.....	.....
Dewitt	4	97	85	600	29	(a)	.....
Dickens	1	45	.....	.....	29	.....	.....
Donley	5	52	50	256	38	(a)	(d)
Duval	1	64	.....	.....	33	.....	.....
Eastland	1	68	.....	.....	.....	.....	.....
Ector	2	25	20	100	.....	(a)	.....
El Paso	1	16	.....	.....	25	.....	.....
Erath	2	62	.....	200 to 640	50	.....	.....
Fisher	3	47	35	.....	50	(a)	.....
Foard	10	51	64	150	26	(a)	33 to 50
Gallagher	1	40	10	.....	40	.....	.....
Galveston	1	200	.....	.....	.....	(a)	.....
Goliad	1	70	.....	.....	.....	(a)	.....
Gray	1	50	.....	.....	.....	(a)	.....
Grayson	1	210	.....	.....	.....	(a)	.....
Hale	1	32	.....	.....	.....	.....	.....
Hall	3	52	.....	.....	.....	(a)	(d)
Hansford	3	40	10	.....	29	(a)	.....
Hardeman	1	45	11	.....	.....	.....	(d)
Hartley	1	64	64	160	.....	(a)	.....
Hemphill	5	34	28	.....	12	(a)	(d)
Hopkins	4	83	75	200	50	.....	.....
Hood	.....	.....	.....	.....	50	.....	.....
Howard	3	32	30	200	.....	(a)	.....
Hutchinson	1	.....	.....	.....	33	.....	.....
Irion	2	52	40	120 to 200	33	.....	(d)
Jack	2	64	.....	.....	50	.....	.....
Johnson	1	200	.....	.....	.....	.....	.....
Jones	1	5	.....	.....	33	.....	.....

a No decrease except through occasional bad seasons. b Decrease from brush.
c March to November. d Marked improvement. e In twenty years.

County.	Number of persons reporting.	The present carrying capacity of the ranges; number of head per square mile.			Estimated percentage of increase or decrease in carrying capacity of the range in a period of twenty-five years.		
		Cattle.	Horses.	Sheep.	Decrease (per cent).	Neither decrease nor increase.	Increase (per cent).
Karnes	1	100	58	220	75	.....	.....
King	1	45	.....	.....	30	.....	.....
Knox	2	52	40	.....	38	.....	.....
Lasalle	1	60	50	640	50	.....	.....
Lipscomb	4	40	25	.....	50	.....	(a)
Live Oak	1	80	60	640	b 25	.....	.....
Lubbock	2	32	25	250	38	.....	.....
Lynn	2	40	32	.....	c 50	.....	.....
Matagorda	2	132	80	500	38	.....	.....
Maverick	1	33	24	170	40	.....	.....
McLennan	1	100	.....	.....	.....	(d)	.....
McMullen	2	70	45	420	23	.....	.....
Midland	7	30	24	104	c 33	(d)	(a)
Menard	1	.....	.....	.....	.....	.....	(a)
Mitchell	5	53	40	150	.....	.....	(a)
Montague	5	68	60	225	45	.....	.....
Moore	2	50	.....	.....	33	.....	.....
Nolan	4	48	30	300	40	(d)	.....
Nueces	5	74	60	850	b 35	.....	.....
Ochiltree	1	57	.....	.....	80	.....	.....
Oldham	1	35	.....	.....	33	.....	.....
Palo Pinto	3	80	75	1,200	38	.....	40
Parker	1	100	50	.....	.....	(d)	.....
Potter	10	32	30	200	25	.....	.....
Presidio	1	30	30	60	.....	(d)	.....
Rains	3	57	62	150	65	.....	.....
Randall	1	64	.....	.....	.....	(d)	.....
Roberts	5	34	20	.....	33	.....	.....
Runnels	2	75	50	300	18	.....	.....
San Augustine	1	83	.....	.....	20	.....	.....
San Patricio	3	56	40	.....	b 50	.....	.....
San Saba	2	65	30	120	28	.....	.....
Scurry	2	38	25	.....	25	.....	.....
Shackelford	6	64	55	250	.....	(d)	.....
Sherman	1	60	.....	.....	.....	(d)	.....
Starr	1	35	.....	.....	66	.....	.....
Sterling	3	45	32	.....	83	.....	(a)
Stephens	4	64	45	450	31	.....	.....
Tarrant	5	96	80	620	.....	(d)	.....
Taylor	1	64	60	.....	10	.....	.....
Throckmorton	1	32	.....	.....	30	.....	.....
Titus	3	20	.....	.....	70	.....	.....
Tom Green	12	53	39	210	33	(d)	(a)
Uvalde	1	60	30	250	50	.....	.....
Valverde	2	50	.....	150	33	(d)	.....
Victoria	4	122	.....	.....	.....	(d)	(a)
Waller	1	210	.....	.....	.....	.....	.....
Ward	5	17	17	120	50	.....	.....
Wheeler	2	35	30	.....	38	.....	.....
Wichita	3	66	.....	.....	24	.....	.....
Wilbarger	9	44	32	112	28	.....	.....
Williamson	3	48	25	100	40	.....	.....
Wise	1	100	.....	.....	30	.....	.....
Wood	3	90	.....	.....	80	.....	.....
Young	12	60	35	.....	42	.....	.....
Zavalla	1	55	28	.....	.....	.....	100

Number of counties	115
Number of stockmen reporting cattle	302
Average carrying capacity, cattle, per square mile	64.8
Number of stockmen reporting horses	67
Average carrying capacity, horses, per square mile	33
Number of counties where carrying capacity has decreased	82
Average percentage of decrease	40
Number of counties reporting improvement in pastoral conditions	19

a Marked improvement.
b Decrease from brush.
c Decrease from prairie dogs.
d No decrease except through occasional bad seasons.

According to the above data it will be seen that the average grazing capacity of the State as a whole, as reported by 302 stockmen, in 115 counties, is a trifle over 64 head per square mile, or 1 head to 10 acres.

The estimated average decrease in the carrying capacity amounts to 40 per cent in 82 counties, while in 19 counties a marked improvement in the pasturage within recent years is reported. Accepting this estimate of a 40 per cent average decrease, the grazing capacity in former years must have averaged at least 106 head of stock cattle to the square mile. This loss, in the central and western portions of the State, is almost entirely due to the ravages of prairie dogs and to putting too many cattle on the land. Farther south the encroachment of brush and cactus and a large increase in the number of jack rabbits are additional causes. The pecuniary loss which the stock owners of the State have sustained since 1883 is not the only evil arising from grazing too many cattle on the land. Overstocking not only causes loss of cattle and sheep from starvation in time of drought, but it causes the rapid extermination of the most valuable of the native grasses and forage plants. In any pasture the grasses which are first eaten down are those which are most nutritious or most palatable. Unless the pasturage is fostered and these best grasses are protected by resting or by artificial care and cultivation, they are soon reduced in number and become unimportant factors. They are prevented from ripening seed and are eaten so close that often the roots are killed by exposure. The first result of overgrazing is the disappearance of the best grasses, that is, a lessening of the potential carrying capacity of the pasture. If the best grasses cover 25 per cent of the range, the loss from overgrazing will be at least that amount. If the pasture is still overstocked, a similar process is continued with the remaining species until at last there is not a blade or fragment of a stem left to support any grazing animal. The young shoots are eaten off as rapidly as put forth by the plant and the vitality of the plant is sapped, so that it is unable to endure extremes of temperature or shortage of water supply to the same degree as when its growth has been uninterrupted. It has been noted that very often in times of drought the best grazing grasses, such as sedge grasses, needle grasses, gramas, and curly mesquite, which will ordinarily withstand the hardest usage, are destroyed root and branch by being eaten into the ground. Not only is the grass destroyed, but the ground over extensive areas is trampled and compacted by the cattle until every sprig that grows upon it breaks up and is blown away. Following the destruction of the valuable perennials, the low annuals, such as the six weeks' grama, come in and supply almost the only feed. At the same time that the valuable grasses are disappearing the land is being invaded by a vast number of rampant weeds which are not eaten by any grazing animal.

It is the opinion of a majority of stockmen who replied to the question as to the amount of range deterioration, that there has been a very large loss in what may be called the capital value of the grazing lands within a very short period. The land which is made poor by this stripping process suffers actual decrease in fertility through exposure

of the surface layers to the sun and air. Soils which are covered with verdure are always fertile and those which lack a protecting plant covering are sterile and deficient in "life." Overgrazing also subjects the soil to the destructive action of torrential rains. When rain falls upon any field thickly covered with grass or other vegetation, the surface drainage is much retarded because the total surface for the retention of water is largely increased; but when the grass is eaten off, or destroyed in any other way, not only is less of the rainfall absorbed but the full force of the rushing waters is exerted upon the exposed surface, and vast quantities of the finest and richest parts of the soil covering are washed into the streams. This denudation of land by the destruction of its grasses, while perhaps not so familiar as that following from the destruction of forests, nevertheless is proceeding quite rapidly in a great number of places in the West. The washing away of the soil proceeds less rapidly on the plains where the slopes are less abrupt than in the mountains, but the result is just as sure, although the obvious destruction is less marked. Wherever grasses are allowed to fully mature and are not entirely eaten down, there is a decided difference in the amount and rapidity of the drainage. Less water runs off into the streams in the form of floods and more is absorbed into the soil. These are the various results of the evil course of overstocking the grazing lands of the West, which if persisted in will surely supply another example of the transformation by human agencies of a fertile land into a desert waste.

DESTRUCTION OF GRASSES BY ANIMAL PESTS.

In addition to the destruction of the grasses by stock, the number of grass-eating pests, especially prairie dogs and jack rabbits, has rapidly increased. These were formerly kept in check to a large extent by their natural enemies, but when the bulk of the gray wolves and coyotes were killed off by the stockmen, on account of their depredations among sheep and young cattle, there was nothing to prevent the grass destroyers from rapidly increasing and spreading out over new territory. Another potent cause of the spread of these pests to new land is the destruction of the grass and the consequent diminution of their natural food supply. There are now hundreds of square miles of prairie-dog towns in the central and western portion of the range country, while in the South the jack rabbits are becoming very numerous. Five jack rabbits will consume enough grass per annum to keep one sheep, and twenty prairie dogs will eat and spoil even more. Like the rabbits in Australia, both of these pests breed rapidly, so that it takes only a short time after the decimation of either one by epidemics or by poisoning to fully recruit their numbers. Poisoning can be made effective if there is concert of action among the stockmen in any given locality. The dogs and rabbits must be killed in all the pastures within a district. To destroy them in one pasture or township and not in the

adjoining ones amounts to throwing away time and money. There is great need of systematic effort to check the increase of both rabbits and prairie dogs. The amount of forage annually destroyed by them is enormous. The loss of grass is distributed among a large number of stockmen, and so is not felt in its entirety by individual owners, but the loss in taxable values to the counties and the State is no small one. The grass eaten by 100,000 rabbits would support 20,000 sheep, and there are many counties in southern Texas where this would be a very moderate estimate of their numbers. In the heart of the prairie dog-infested region the writer has seen extensive villages where, at a very conservative estimate, there were from 2,000 to 5,000 prairie dogs to the square mile. Now, on a square mile of land so infested the dogs eat and defile grass enough to maintain from 100 to 250 sheep per annum. Prairie dogs will not tolerate tall grass near their burrows, probably partly on account of the cover thus given to their enemies, and partly because these grasses are better relished by the dogs. They dig up the roots of all of the more succulent species, like the sedge grasses, and permit only the low turf formers to remain. The dog-village grasses are needle grass, curly mesquite, woolly oats (*Triodia avenacea*), and, in western Texas and New Mexico, hard grass (*Scleropogon brevifolius*), a harsh-stemmed turf-former seldom found in abundance anywhere else. Some of the grasses that occupy the prairie dog-infested land are intrinsically valuable for grazing, especially in winter when cured on the ground, but they lack the bulk of the taller kinds which would grow on the land if the prairie dogs were killed. Lands occupied entirely by these grasses are not and can not be called productive; they have reached almost the lowest stage of deterioration, and are next to valueless for grazing purposes. The extermination of prairie dogs and jack rabbits means a great deal if the grazing industry is to be developed to its fullest extent.

DETERIORATION THROUGH INCREASE OF WEEDS.

Another factor which is tending to decrease the carrying capacity of the ranges, as a whole, is the rapid spread of prickly pear and thorny shrubs in the South and of the mesquite bean on the table lands and higher prairies. At certain times or in certain seasons both the prickly pear and the mesquite bean are of some value as sources of food, but their increase can not be looked upon as wholly beneficial.

PRICKLY PEAR.

The flat joints of the prickly pear (*Opuntia engelmanni*) are mucilaginous and watery, and in times of drought serve to some extent as food, or, more especially, water. Cattle and sheep may be kept alive for several months on prickly pear when all other forage has become dried and broken and has blown away—a state of affairs that often occurs during a severe drought. At such times, if the stockman

has put his trust entirely in the native herbage and the natural water supply and has made no provision for bad seasons by putting up hay or by digging wells or making storm water tanks, the prickly pear may be considered a valuable forage plant, as without it the stockman could not bring his cattle through the drought alive. But in the good years—and there are a great many more good years than bad ones—the prickly pear takes up space that might be better filled by grasses, for when there is plenty of grass, cattle do not touch the cactus, and its rank growth shades and chokes out the better forage. In the lower valleys, from the Guadalupe River west, this cactus forms thickets with the various spiny shrubs that compose the "chaparral"—tangled copses with paths winding here and there among clumps that are each year becoming more impenetrable. The only grasses that thrive here are shade-loving species, which, compared with those that grow in the full sunlight, are unpalatable and of little feeding value. A few sprawling stems of some of the better and formerly abundant grasses struggle upward toward the light wherever protected from extermination by the sharp-spined cactus, but it may no longer be called a well-grassed country. From the standpoint of the botanist the prickly-pear thickets are splendid collecting grounds, but from the standpoint of the ranchmen the increase of cactus, rapid in good years and slow in bad ones, is extremely prejudicial and withal disheartening. Scarcity of rainfall does not seem to influence the prickly pear the same way as the grasses, the former simply holding its own during times of scarcity and shooting ahead with renewed vigor when the rainfall becomes normal, the latter quickly dying to the ground. On the southern prairies the stockmen have seen the change within fifteen or twenty years from open country, covered knee-high with luxuriant grasses, to a tangled thicket with grasses only at intervals, and the prickly pear so thick that it is hard to drive cattle through it.

How to destroy prickly pear.—Fire is the only remedy which is always effective in fighting the prickly pear, but to develop enough grass and undergrowth so that a fire will run through thickets composed of this cactus requires that cattle shall be kept out of the pastures one and often two years, and few stockmen are willing to sacrifice two years' growth of grass even to rid themselves of the prickly pear. Mr. William Benton, of Nueces County, estimates the loss of pasturage from encroachments of prickly pear within the last ten years at from 25 to 35 per cent, year in and year out, and the present outlook is worse rather than better. In other words, lands which have not suffered to any appreciable extent in actual fertility, or in what may be called the potential fertility of the soil constituents, have only the capacity of producing from two-thirds to three-fourths as much forage now as ten years ago, although they are at present covered with a far greater bulk and amount of vegetation. Many stockmen who have noted the progress of this pest are of the opinion that in another twenty years prickly pear will cover a large part of the now open or fairly open

grazing lands in the southern part of Texas, to the detriment of all stock and land owners. As to the cost of destroying prickly pear by means of fire, take, as an example, 1 square mile of land which will carry 64 head of stock cattle the year round without winter feeding. It requires three years to mature a steer, so that the grass product of the square mile for one year will be equivalent to the amount of forage necessary to fully mature 21 head. It has been estimated that a cow or growing steer of 1,000 pounds live weight requires per day in pasture about 110 pounds of green grass, containing from 24 to 27 pounds of digestible food. At 110 pounds per day this would amount to 20.07 tons of green grass per head of stock per year. Hence a pasture that carries 1 head to 10 acres must produce at the rate of 2 tons of green grass per acre. Taking $20 as a fair average valuation for the cattle, the market value of the grass turned into beef would be 21 times $20 or $420, per square mile per annum, or about 66 cents per acre. Sixty-six cents per acre would, according to the factors assumed, be the money loss in grass if the pasture were burned after a lapse of one year. It is doubtful whether any other method anywhere near as cheap could be used to destroy the prickly pear. To be the most effective the pasture should be burned in spring just after the new growth has commenced, because the cactus is then most easily destroyed. The young and tender shoots would be scorched and cooked and prevented from further development, and the singeing off of the spines on the older shoots would expose them to destruction by animals. The fire would also check the development of the weeds and brush that thrive in the shelter of the clumps of cactus. If hogs or goats could be herded on the prickly pear after the fire, the destruction would be much more complete. Goats especially are good scavengers to clean up weeds and all kinds of noxious rubbish.

The following statements serve to illustrate the change that has taken place in southwestern Texas through the increased growth of prickly pear. Bartlett* says:

> About the parallel of 29° 30′ the table-land breaks off into numerous spurs, descending to the great plains or prairies, which extend in a broad belt from 150 to 200 miles in width. The whole of this district consists of gently undulating plains, *without timber save along the margins of the streams*, and is covered with the most luxuriant grass. The indigenous prairie grass is tall, coarse, full of seed at the top, and when young resembles wheat in the spring. But in grasses the glory of the State is the mesquit, found only in western Texas. It yields a fine soft sward, preserves its verdure in the winter, and beyond all comparison affords the best wild pasture in the world.

Now this same region is covered with brush and cactus. Again describing the country between the Rio Grande and Corpus Christi, Bartlett says that the chaparral only occupied the immediate Rio Grande Valley, a strip 6 to 8 miles wide, and that beyond this to the northward there was a rolling prairie with a few scattered bodies of cactus and low mesquite trees.

* Bartlett, Personal Narrative, 1854, Vol. II, p. 566.

THE MESQUITE BEAN.

The mesquite bean (*Prosopis juliflora*) has a very wide natural distribution from Texas to Argentina. It is one of the characteristic trees of the lower Sonoran zone, an area where the conditions as to rainfall and climate range from arid to semiarid—that is, the rainfall varies from less than 10 to about 25 inches per annum. With the exception of the coastal plain immediately bordering the Gulf, all of the best grazing lands lie within this zone. In habit of growth the mesquite bean resembles a peach tree with rather scattering foliage. It normally produces from one to three crops of beans every year. The pods are filled with a sweetish pulp, which causes them to be much sought after when ripe by cattle and horses, and stockmen consider them as fattening as grain. The production of pods is governed largely by the season. In a year when the rains are uniformly distributed through the growing season the yield will be light.

Stockmen say that if there is a spring drought followed by abundant summer rains, and then again an autumn drought, the mesquite trees will either make two crops of ripe beans or will shed the first crop before fully ripe and throw out a second lot of flowers in midsummer. This, of course, depends on the stage of growth which the beans have attained when the midsummer rains come. The beans are produced in greatest abundance during the dry years, and are then very valuable forage. The sweet pods are greedily eaten by cattle, and prove almost as fattening as barley or other grain. The yield varies from a few bushels to often 75 or 100 bushels of ripe pods from the trees on an acre of land. The seeds are hard and indigestible, and remain in the dung when the pods are eaten by cattle. They then seem to be even more sure of germination than when the pod is left to rot on the ground. By this means alone this tree is spreading rapidly each year over new territory, the seeds being scattered far and wide by all classes of animals that feed on the pods. In the early days, when the central prairies were sparsely settled, they were burned over each year, and the young seedlings of this and other trees were killed to the ground. Twenty years ago it was hard to find a mesquite bean on the open prairies that was larger than a small shrub. The only places where they occurred of any size were in the valleys and the "timber islands"—small scattered groves at intervals on the prairies, usually about some swale or along a ravine or a rocky knoll. Since the more complete settlement of the country, fires are not allowed to sweep the prairies, on account of the possible loss of crops and improvements. There is nothing to check the growth of the mesquite bean, and they have grown to the size of small trees, at the same time largely augmenting in number.

A mesquite grove has two distinct advantages, viewed from the standpoint of the stockman. It supplies cover during "northers" and

severe winter storms, and it produces varying crops of nutritious beans, often at the time of the greatest scarcity of other feed. On the other hand, there are several disadvantages. These mesquite groves are centers of infection for the range in that they form natural covers for the protection of prickly pear, cat's claw, wild currant (*Berberis*) and other spiny shrubs and noxious weeds. They tend to choke out, by overshadowing, the best and most nutritious sun-loving grasses. Furthermore, the trunks and branches cover quite an area of land on every section, so that it is a question whether the grasses which are displaced during nine good years would not be worth as much or more than the crop of beans during the tenth dry year.

The best grasses are those that grow in the bright sunshine. There is among grasses something of the same adaptation to locality, though perhaps not so marked, as among plants of other natural families. Some grasses—like the gramas, needle grasses, and blue stems—mature only in the bright sunlight, clear and unobstructed; others thrive only in half shade where protected by shrubbery and undergrowth, and others still would be burned out by the direct sunlight in a single day. The feeding value of the grasses also varies directly according to the amount of sunlight which they receive during the growing season, and the grasses that live in the full sunlight are far more nutritious, will fatten an animal sooner, and cause more rapid gain in weight than those which grow either in the woods or in half shade. Viewed from this standpoint, the rapid encroachment of the mesquite bean on the open range must in time be detrimental to the carrying capacity of the range. The consideration of these points must enter into the problem of range deterioration and improvement. The wild grasses of the high prairies and table-lands depend upon the flood of sunlight for their high feeding value. If that is cut off or the light rays are interrupted by the foliage of trees, the inherent fattening qualities of the grasses are lessened. In this way both the individual cattle owner and the State will suffer. The individual losses may seem very small and unimportant, but in their aggregate they amount to no inconsiderable sum, which must be subtracted from the total working capital of the State.

RENEWING THE CATTLE RANGES.

That the natural pastures are in need of practical and scientific treatment in order to increase their grazing capacity no one who is acquainted with their past and present condition will deny. The most obvious methods of bringing about the desired improvement are either resting for several seasons to enable the grasses to retake the land which has been denuded of its most valuable grasses, or cultivating the surface of the pasture in order to accelerate the gradual natural processes.

Besides these, there is need of finding out what can be done in the

way of cultivating the best native grasses, of increasing the number of valuable sorts by introduction of foreign species, of determining whether a stand of certain forage plants may be secured by sowing the seeds on the unbroken sod or on land which had simply been harrowed, and of determining the practicability of inoculating range land with turf-forming grasses.

For the purpose of carrying on such experiments two sections of land have been leased by this Department, one at Channing, in Hartley County, Tex., which will represent, in a large measure, the conditions that prevail in the high plains of the Panhandle, and one at Abilene, Tex., to serve for the central and western prairies up to the border of the Staked Plains. On each of these sections three 80-acre and two 40-acre pastures have been fenced and are being treated as follows:

Pasture No. 1.—No treatment except to keep stock off until June 1, pasturing the balance of the season.

Pasture No. 2.—Cut with a disk harrow and keep stock off until June 1, pasturing the balance of the season.

Pasture No. 5.—No treatment except pasturing until June 1, and keeping stock off the balance of the season.

Nos. 1, 2, and 5 each contain 80 acres. Pastures numbered 3 and 4, each consisting of 40 acres, are being grazed alternately, the stock being changed from one pasture to the other every two weeks. In addition to these fenced and stocked pastures, 80 acres of land were dragged with an ordinary straight-toothed iron harrow, one 80-acre tract was disked, and a third was left as a check without any treatment whatever except that, in common with the other two, no stock was allowed to run on it during the first season. The remaining 80 acres are devoted in part to the cultivation of grasses and forage plants, using both such as can be obtained in the markets, and the native sorts, while a portion has been set apart for minor experiments. Among the latter may be mentioned the breaking of east and west furrows at intervals in order to intercept and catch the seed of the needle grasses and other bearded seeds which are blown over the ground by the prevailing north and south winds; the sowing of seeds of various wild and cultivated forage plants directly upon the sod without other treatment, and experiments in transplanting the best of the wild turf-forming grasses to bare spots by setting bits of turf in the ground with a spud or simply pressing them with the boot heel into the soft earth after rain. On some portions of this 80-acre field, experiments will be made in sowing alfilaree, bur clover, Bokhara clover, and valuable wild forage plants which grow in other similar regions directly on the sod without further treatment than to keep stock off during at least the first year. The section at Abilene was inspected before the commencement of the work by a committee of stockmen who made an estimate of the carrying capacity of the land at that time. It will be judged at intervals throughout the experiments by the same committee in order to determine as exactly as

possible the rate and percentage of improvement in the different pastures under the different methods of treatment. These experiments will be carried on for three years, at the end of which time sufficiently definate results ought to be secured to enable the stockmen to decide what is the most practical method of bringing back the grasses. On the cultivated land a large number of species will be tested in regard to their adaptability to semiarid conditions. Not only will the seedsman's lists of grasses and forage plants be drawn upon, but a special effort will be made to cultivate such native plants as tallow weed, Metcalfe bean, Texas pea, and Buffalo pea. From the results thus far secured at the close of the first season's work, it would appear that the land which has been disked is improving at the most rapid rate. Even at the rate of 40 cents per acre, which was paid for the work, this treatment costs fully one-third less than simply resting the land without treatment, and more than enough grass can be secured from the disked land the first year to pay for the cost of the labor.

The best results have accrued from loosening the surface of the ground in early spring before the grasses commence their new growth. It stimulates the roots of such grasses as are already established, causing them to grow with renewed vigor. At Abilene at the close of the season (October 15, 1898) it was estimated that the grasses on land which had been disked in the early spring had improved at least 25 per cent in carrying capacity—that is, there was 25 per cent more grass on the land at the end of the first season than appeared on adjoining pastures which were not treated in any way. Both pastures were grazed with the same amount of stock and treated as far as possible alike. The experiments here referred to were commenced in the spring of 1898.

REST VERSUS ALTERNATION OF PASTURES.

A great many of the stockmen who have reported concerning the state of their ranges have suggested that the resting of the land would be the cheapest and most practicable method of again bringing it up to its highest value. Resting is an excellent treatment wherever sufficient grass remains to reseed the land. It is, however, not the most rapid method, nor can it be considered the cheapest when one takes into consideration the fact that the land to become fully regrassed must be rested sometimes three or four years. Complete resting of a pasture is really a more expensive means of improving the pasturage than many would suppose. As shown above, in the case of range deterioration through the growth of cactus, the grass on an acre of land on a section capable of carrying 64 head of stock cattle is worth 66 cents per acre when the cattle are appraised at a valuation of $20 each. At this rate the cost of the renewal of the pasture in the course of a few years would amount to very nearly the value of the land.

Partial resting, or resting during different seasons of the year, a system which may be designated the alternation of pastures, secures the same result at much less expense. Thus a range might be divided up into a number of small pastures provided with water, in each of which the cattle would be allowed to run for not more than two or three months at a time and then be transferred to another. In this way the succession of grasses which normally occurs in nature can be fostered and improved. Let us suppose a range of 100,000 acres in extent divided into ten pastures of 10,000 acres each. At the average carrying capacity for the State this body of land will produce forage enough to sustain 10,000 stock cattle throughout the year. These divided up into their various classes—beef steers, two-year olds, and yearlings, cows and calves—could be held three months in one pasture and then transferred to another which had been kept free from stock during that engtth of time. A rest of two or three months during the growing season in early spring would enable the early grasses to ripen and shed their seeds, thus perpetuating the early species. After the seed had fallen, the cattle could be turned on the grass for two or three months and again transferred to a fresh pasture. In the same way autumn and winter pastures can be secured. Several stockmen who have employed this method on a large scale for a number of years say that their ranges are continually improving, in marked contrast to the deterioration that had occurred through bad treatment of neighboring properties where the old methods were practiced. It is also claimed that pasture land thus treated will carry more head of cattle through the year and bring them out in better condition than where the herd has access at all seasons of the year to all portions of the range. Where winter feeding is practiced in connection with alternation of pastures, the very best results may be obtained at the least cost, and the owner will find that with judicious care the value of his property will constantly increase and the annual profit as represented by the increased number of marketable steers will more than compensate for the cost and labor of changing cattle from one pasture to another.

ADDITIONAL AIDS TO RANGE IMPROVEMENT.

In addition to the methods of improving the range by cultivating the surface of the ground, raising native grasses, plowing occasional furrows to arrest the wind-borne seeds, and scattering the seeds of native and introduced forage plants on the unbroken sod, the cultivation of the ranker and bulkier forage crops should be encouraged. On almost every ranch there are strips of valley lands, or often extensive meadows, which are naturally well watered, or which are so situated that they may be irrigated from artificial tanks. These lands should be put into cultivation. The rancher is often loath to incur the expense and trouble necessary to grow and cure a patch of sorghum or of some hay grass, but the possession of a sufficient amount of

cured fodder or hay will insure him against excessive loss as the result of drought or of the rotting of the natural pasture grasses through autumnal or winter rains.

STACK SILAGE.

The practice of making good hay from alfalfa, cowpeas, Johnson grass, the sorghums, and other coarse or succulent plants is often attended with much difficulty, and the product varies in quality and value according to treatment. Successful hay making requires considerable experience, besides taking time and a large force of laborers, so that the expense of preparing a cured crop often amounts to very nearly its feeding value. The fact that it requires a number of men will sometimes prevent cattle owners from trying to put up any hay. The desirability of having a quantity of green, or at least succulent, feed during times of drought and during late winter and early spring months is well recognized. In the farming districts that want may be supplied by the cultivation of soiling crops, root crops, and by putting up silage, the latter prepared in strongly built silos. The cost of building a silo precludes its use by the majority of farmers and stock owners, especially in the more sparsely settled districts and in the arid and semiarid portions of the Southwest, where lumber and labor are high priced. Fodder and hay are very desirable, but they must be cheap and easily prepared else they will not be used. Stack silage or open-air silage is extensively used in portions of Australia, South Africa, and northwest India, where the general conditions as to fertility of the soil, rainfall, and climate are about the same as in Texas and the Southwest.

It is claimed that the value of stack silage was first discovered about 1867, when a New Zealand farmer whose haying operations were interrupted by heavy rains, raked the green, freshly cut grass into a great pile, his idea being to save the, as he supposed, rotten mass for fertilizing purposes during the coming season. Instead of the grass rotting a fermentation took place and the product was eaten greedily by stock which were turned into the field during the winter. Whatever may be the source of the practice, the fact remains that stack silage finds a very wide use in hot countries among stock farmers and men whose means do not permit them to purchase silage cutters and build silos.

The theory of making silage is to pack the green forage into a compact mass, thus preventing the entrance of air into the material. The green mass undergoes a sufficient fermentation to partially cook and preserve it. In building a silo the walls are constructed of heavy timbers, braced and covered both inside and out with sheathing, tar paper, and matched boards, made as nearly as possible air-tight, for it has been found that wherever air penetrates into the mass or the fermentation is carried too far the silage becomes moldy, producing an indi-

gestible mass. Where air has free access during fermentation, the process will be carried too far, but where the amount of air is limited the fermentation is only carried to a certain point and the palatability of the food is improved. It has been found that a silo and fodder-cutting machines to chaff the stems into small pieces are entirely unnecessary in dry climates. Instead, the green grass or green fodder is raked and stacked as soon as cut. Then, when the pile has been carried up as high as convenient, weights are put on the top and the sides are trimmed down perpendicular with a hay knife. This method produces a sweet silage, which has very nearly the same feeding value as silage prepared at greater cost in built silos.

Mr. Fred Koehler, of Bee County, Tex., has used stack silage made of sorghum, and considers it, when fed in connection with cotton-seed meal and hulls, the cheapest and best fattening material for top-ping off beef steers for the market. He builds a sort of paling fence, using 4- or 6-inch fence boards in 10 to 16 feet lengths, woven together with heavy galvanized fencing wire, leaving about a 2-inch space between the boards. The length of this fence can be accommodated to the diameter of the stack which it is desired to make. When the sorghum is ready to cut, which is about the time that the seeds are commencing to harden, one of these paling fences is set up in a circle, varying from 12 to 20 feet or more in diameter. Then using horse rakes, loaders, and stackers, the freshly cut or slightly wilted sorghum is fed over the tops of the boards into this pen, and the process is continued until the pen is filled. During the filling, the fodder is stamped down around the edges so as to leave no air spaces. When the pen is filled to the top a layer of straw is added and built up to a peak to shed rain. On this is piled dirt or stones or bags of earth to the depth of 2 or 3 feet, in order that the pressure shall range from 125 to 200 pounds to the square foot. Pressure may also be applied by means of a Span-ish windlass or by levers. The palings remain in place until the stack has settled and compacted sufficiently to stand alone, when they may be removed and set up elsewhere and the process repeated.

It has been found that by applying the pressure at the right time one may readily control the fermentation and produce either sour or sweet silage as desired. Thus, if the fermentation is not allowed to proceed above 130° F., if the stacks are weighted when this tempera-ture is reached sour silage is produced. If the fermentation is allowed to go on until the temperature rises to between 150° and 165° F. before the stacks are weighted, the mass will often become highly carbonized, appearing dark brown, or almost as black as charcoal, but the silage is sweet and relished by cattle. Sour silage is considered more satisfac-tory for dairy purposes than sweet silage.

The possibility of preserving large quantities of the coarser forage-plants by this method will undoubtedly prove valuable for extensive districts in the arid grazing regions. It will not, however, be adapt-

able to humid climates. Wherever the rainfall amounts to more than 25 or 30 inches, or where the air is moist through a large part of the year, silos will have to be built. The manufacture of stack silage opens great possibilities and will enable stockmen to increase the number of cattle upon the range. If palings are not available for confining the silage and making the sides perpendicular, the stack may be built up in the same way as a haystack. At the close of the operation, after the forage is well settled and compacted, the looser outside portions may be trimmed off perpendicular with a hay knife and piled on top of the stack as a thatch.

Corn can not be depended on as a forage plant in semiarid regions. The best crops, and those which seldom fail, are sorghum, milo maize, Kafir corn, and Johnson grass, the latter for the richer bottom lands. Of the first three forage crops, from 10 to 20 tons of the green forage may be secured per acre, and at least two cuttings, from 4 to 8 tons each, of the Johnson grass. Two crops of sorghum may often be grown on the same land in one season. Fodder made from the sorghums is rather difficult to cure, or, to speak more properly, is difficult to handle after curing, on account of its bulk and the harshness of the leaves and stalks. Moreover, in the dry climate of the Southwest much of the best part of the fodder and leaves is lost in the process of handling, because becoming so dry and brittle. The stalks are also tougher than cornstalks, and there is more waste in feeding.

In the case of Johnson grass there are grave objections to its use for hay on a large scale, because of its weedy character when introduced into farm lands. The territory where Johnson grass is the most valuable hay grass, comprises the red prairie region, which includes the headwaters of the principal streams that in their lower courses flow through the rich farming lands of eastern and southern Texas. The seeds of this grass are liable to be washed down from the headwaters in time of flood, inoculating new fields with this, to the cotton farmer, undesirable pest. If the Johnson grass is turned into stack silage instead of being made into hay, the danger of spreading a bad weed will be obviated, because the germinating power of whatever seeds may be in the stack will be destroyed by the heat generated in the course of fermentation.

The principle of stack silage is not by any means a new one. The methods of curing clover and alfalfa in cocks are practically the same, as are also those of curing green corn and sorghum in shocks. In such cases fermentation of the partially wilted substance takes place, the difference being that the fodder in shocks ferments at a much lower temperature than in stacks. Thus silage can be made at very much less expense than hay. Enough has been done by stockmen and feeders to show that stack silage is not an experiment, but is entirely practical. It is probable that much may be added to our knowledge, especially in regard to such details as the best height and width of the stacks and

in regard to the time of maturity of the crop from which the silage is to be made. It will also have to be determined whether the leguminous forage crops, such as alfalfa, soy beans, and cowpeas, can be put up in the same manner or whether they can be added in alternate layers in the stack, as is often done in the manufacture of silage in air-tight silos. The principal caution in putting up such stacks will be to see that no large cavities are left in the material, for wherever too much air has access the fermentation is liable to be carried to the putrefactive stage, following which molds will grow and render it very injurious, if not actually poisonous. These precautions are less necessary in the case of Johnson grass or broadcast sorghum, because the mass will be much more compact.

HAY.

In addition to putting up considerable quantities of stack silage, it is advisable that cattle owners provide hay, if a supply can be secured from natural or artificial meadows on the ranch. Very often stockmen who have not made this provision have to buy feed during winter, especially during the heavy snowstorms in the spring before the new grass has started and after the prairie grasses have either all been eaten off or have been rotted by rains or melting snows. In such cases hay often sells from $10 to $20 per ton and is hard to get in time to prevent losses. Prairie hay can be put up at the cost of usually not more than $1 to $2 per ton, using modern machinery and appliances. With the large number of kinds of hay grasses to choose from, any rancher who has fairly good land has no excuse for not putting up enough hay to carry his stock at least through the severer storms of the winter.

WATER.

Another precaution that must be taken, if the stock ranges are to be restored to anything like their former value, is that water must be provided in sufficient amount so that cattle will not have to travel long distances for it in times of severe drought. Nearly the entire western portion of Texas is underlaid by artesian waters ranging from 150 to 1,500 feet below the surface. Wherever the drainage slopes are not too precipitous, artificial tanks may be formed across the draws by building dams, and if the bottom of the tank is carried down to hardpan, or is puddled before being filled, a supply sufficient to last through the dry season may be secured at small expense. Such tanks, or wells, either artesian, or where the water is lifted by windmill pumps, should be provided at least every 4 miles over the range, so that cattle will never have to travel more than a couple of miles to water. Where the wells, water holes, or tanks are 8, 10, or more miles apart, as they very frequently are on some of the western ranges, cattle greatly overstock the range in the vicinity of the water, especially during midsummer, while the back country is thickly covered with good feed. Thus a

portion of the range will be overstocked while another portion will be undergrazed. In the one case the grasses are eaten down and trampled for a few miles back from the water so that it may require several good seasons to undo the injury done in one bad year. In addition, the forage on the large area back from the water is entirely lost through not being grazed. The cost of constructing dams or providing windmills will often be but a small percentage of the loss incurred when no water is provided. It has been often observed that the period of flow of the rivers in countries which have been overgrazed is very much less than it was formerly. This is because the trampling of the herds has compacted the soil, and also because the waters are not retarded from running off the surface as they would be when the land is covered with a thick coating of grasses. Hence the drainage of the surplus water takes place in a very much shorter time. There are many streams and springs which in former years afforded a continuous supply throughout the dry season, which now only run during or immediately succeeding periods of abundant rainfall. Thus less dependence is to be placed upon the streams as a source of stock water. New artificial sources of supply must be provided.

GRAZING REGIONS IN TEXAS AND NEW MEXICO.

Texas may be divided into seven or eight well-defined agricultural provinces, each differing from the others in the general character of the soil and amount of rainfall. These differences of soil are mainly due to difference in geological formation, while the causes of the climatic variation are the natural phenomena which govern continental conditions, such as altitude, proximity to the Gulf, and presence or absence of vegetation. The areas or belts where soils and natural conditions are alike, or have only casual differences, are usually marked by the growth of certain plants, which form a characteristic, though not always the most prominent feature, in the grass flora. The region under discussion may well be divided along these lines and treated by areas.* These are:

The Coastal Prairies, bounded by a line drawn parallel with the coast about 70 miles back from the Gulf.

The Cactus Plains, which include all of the region between the Colorado and Rio Grande from the border of the coastal prairies to the "rim" of hills that breaks to the northward from San Antonio, just below the thirtieth parallel of latitude.

The Middle Plain, a low table-land, rather mountainous, extending from the southern "rim" to the Concho, and from the Colorado to the Pecos. This is the Edwards Plain of the geologists.

The Granite Region, occupying a very limited area in the center of the State between the central plain and the red prairies.

* From data supplied by Prof. Robert T. Hill, of the United States Geological Survey.

The Red Prairies, extending from the Concho to the Red River, bounded on the east by the black lands and on the west by the Llano Estacado.

The Staked Plains, or Llano Estacado, a high level table-land which extends into New Mexico, containing the sources of all the rivers flowing to the eastward.

The Pecos Valley, an elevated valley which has the same soils as the red prairies, but a much smaller rainfall, so that the conditions are arid.

Before the ranges were overgrazed the grasses of the red prairies were largely blue stems or sage grasses (*Andropogon*), often as high as a horse's back. After pasturing and subsequent to the trampling and hardening of the soil, the dog grasses or needle grasses (*Aristida*) took the whole country. After further overstocking and trampling, the needle grasses were driven out and the mesquite grasses (*Hilaria* and *Bulbilis*) became the most prominent species. The occurrence of any one of these as the dominant or most conspicuous grass is to some extent an index of the state of the land and of what stage in overstocking and deterioration has been reached.

There is often a succession of dominant grasses in nature through natural causes, but never to so marked an extent as on the cattle ranges during the process of deterioration from overgrazing. Thus, the grasses in any given valley are liable to change in a long series of years through destruction by wood lice, prairie dogs, by fires, unusually early or late frosts, or by failure on the part of the plant to ripen seed. This latter contingency frequently occurs in the case of the big blue stem and feather sedge, and probably with some other of the Andropogon species. The curly mesquite will stand almost any amount of drought, trampling, and hard usage, but is easily killed and rotted out during a wet, cold winter. The drought-resistant needle grass is frequently destroyed by wood lice over considerable areas. This usually happens in the spring on burned areas after light local showers. Finally, the entire seed crop may be destroyed by early autumn fires. Thus it is seen that through some one of many natural causes a species of grass may be all but exterminated and its place taken by others, often of less value.

On overstocked lands there is uniformly an alternation of needle grass and mesquite at short intervals, unless the overstocking is carried too far, when these perennials give way to annuals and worthless weeds. The carrying capacity then depends almost absolutely on the proper distribution of rainfall through the growing season in order to bring this transient vegetation to its fullest maturity.

THE COASTAL PRAIRIES.

The low-lying prairies along the shores of the Gulf of Mexico constitute a region of very recent geological formation; in fact, so recent

that many of the fossils contained in the strata are identical with the species now living in the waters of the Gulf. The alluvial plain is flat, swampy, and poorly drained, and is intersected by numerous sluggish streams with precipitous banks. The land is well grassed wherever it has not been overstocked, and the vegetation is very similar to that of the savannas and coastal plains in the Gulf States.

Along the immediate coast there is usually a sloping beach backed by a line of not very high nor very broad sand dunes. There are no drifting sand dunes to compare with those along the Atlantic coast except at intervals opposite the "passes" between the coastal barrier islands, where the winds and tides have free sweep from the ocean. Wherever the coast is protected from these by the islands, the only dune is about 100 yards back from high tide, perhaps not more marked than a narrow ridge, a few feet in height, whose surface is well covered with vegetation. On the land side of the dune there is usually a lagoon, and back of this a marsh containing numerous more or less parallel lagoons and sluggish water courses. This marsh extends from 2 or 3 to sometimes 15 or 20 or more miles back along the entire coast line from the mouth of the Sabine River to Aransas Pass.

The dominant grass on the beach between the ridge and the water is usually salt grass (*Distichlis spicata*). On the sand ridge there are *Eragrostis secundiflora*, salt grass, and slender cord grass (*Spartina patens*). On the seaward edge of the marsh, which is frequently inundated, the principal grass is *Monanthochloë littoralis*, a rough, wiry species with extremely short, harsh, and sharp-pointed leaves. This could never be called a turf grass, and yet its interlaced stems form the closest kind of a mat, extending from 100 yards to a mile or more inland, depending on the elevation of the land above high tide. Next in the succession is the bunch salt grass (*Spartina juncifórmis*) (fig. 1), which grows in great tufts 3 to 6 feet across and from 1 to 4 feet in height. The leaves of this are evergreen, harsh, and rather stiff, spiny pointed, and so sharp that they will make a horse's legs sore when he is ridden through or over it. The leaves are resinous, and will burn at any time during the year, smouldering along even through a shower of considerable violence. Between the tufts or tussocks the ground is either bare or covered with low rushes or other insignificant plants. The salt grass supplies fully 90 per cent of the vegetation of the marsh, and often occupies its surface to the almost total exclusion of other sorts.

These salt-grass meadows are well stocked with cattle. Unlike the salt grasses of the marshes along the Atlantic coast, this can not be mown for hay on account of its bunchy nature, and hence grazing is the only practicable method of utilizing the vast amount of forage produced. The bunch salt-grass marshes will carry from 80 to 120 head of stock cattle to the square mile. It is said to be a fine grass on which to *grow* cattle, but they can not be *fattened* on it; at least, that is the opinion of a stockman in Brazoria County who has ranged cattle

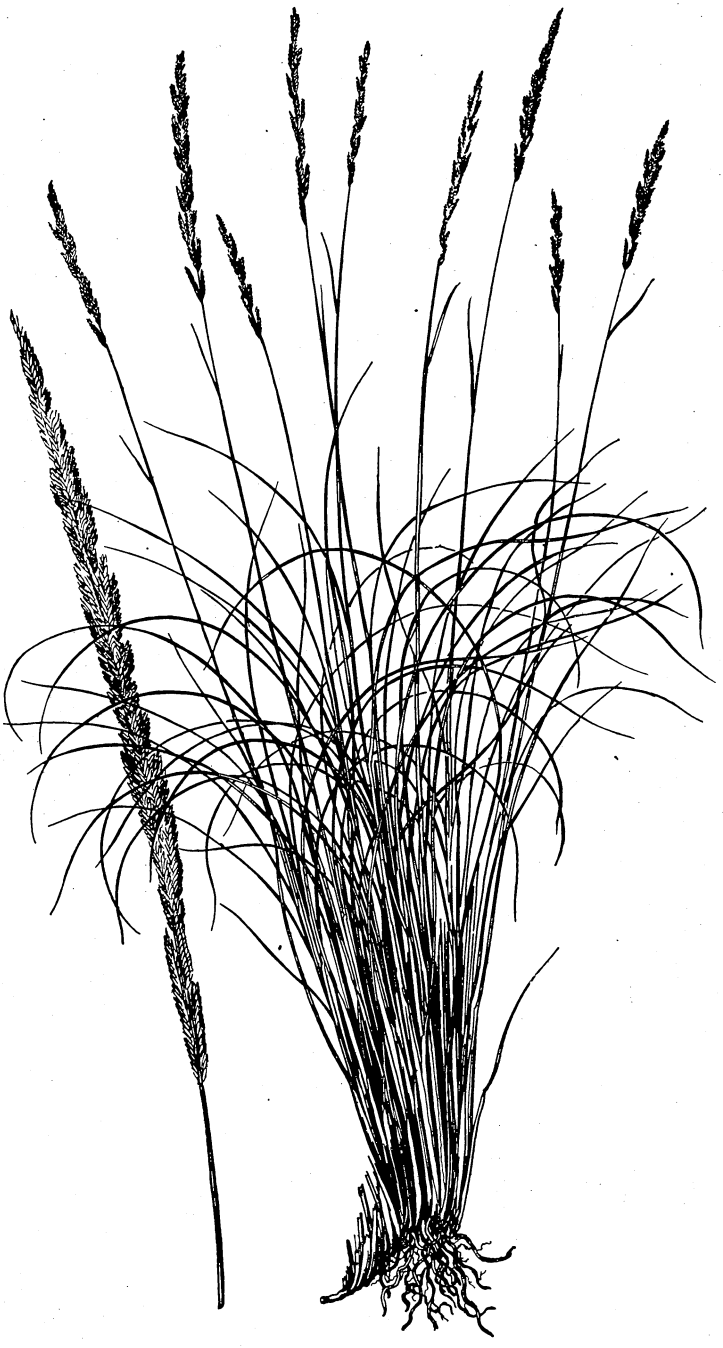

FIG. 1.—Bunch salt grass (*Spartina junciformis*).

on the marshes for forty-five years. When the stock are nearly matured they must be taken to the prairies farther inland or shipped to the fattening pens.

The only treatment ever given the marsh pastures is to burn them over at intervals of three or four years. This clears out the dead leaves and stems that fill the centers of the tussocks and acts as a fertilizer by adding a top dressing of ashes. Marsh soils are as a rule deficient in potash, and hence the marsh grasses need all that which is contained in the ashes. Summer burning should never be practiced on the salt marshes, because to destroy the entire plant to the roots at the time it is in its prime is simply to needlessly sap its vitality; whereas if the grass is burned in late winter or early spring while it is resting, before the new growth starts, the burning over will act as a stimulant to quicken the growth and increase the amount of vegetation.

FIG. 2.—Torrey's sedge grass (*Andropogon saccharoides torreyanus*).

The extent of salt marshes along the coast between the Sabine River and their southern terminus amounts to perhaps 1,000 square miles, which at the estimated grazing capacity as given above can support yearly between 80,000 and 120,000 head of cattle.

The best ranches in this section of the coastal plain are those which extend far enough back from the tide water to include some of the sedge grass prairies and wooded bottoms. The cattle may then be transferred from one character of pasture to another with the changing seasons, thus providing both variety of diet for the growing cattle and also securing that alternate grazing and resting which is most desirable in the formation of the best pastures.

The open prairies, where they still occur, are very fine grazing lands. They are covered with a great variety of species, it often being possible to gather fifty or more different kinds on a single section in one day. The most conspicuous of these are the sedge grasses: Feather sedge (*Andropogon saccharoides*), Torrey's sedge (var. *torreyanus*) (fig. 2), and big blue stem (*A. provincialis*). The first of these is very abundant

and has caused the stockmen to refer to these meadows as the "sedge-grass prairies." However conspicuous these grasses may be, they are not the most abundant. There are a few spots where the sedge grasses occur so thickly that they make up fully 80 per cent of the vegetation. But in the majority of the coastal prairie pastures the sedge grasses do not amount to more than 10 per cent. On prairies at the mouth of the Brazos River buffalo grass (*Bulbilis dactyloides*) comprises about 60 per cent of the total, while rescue (*Bromus unioloides*), knot grass (*Paspalum compressum*), Bermuda (*Cynodon dactylon*), and smut grass (*Sporobolus indicus*) together amount to about 25 per cent. The remaining 15 per cent consists of from thirty to fifty species which occur as scattered individuals. The land is here more suited to agriculture than to stock raising. The rainfall is so heavy that the autumnal and winter grasses are frequently rotted instead of curing into hay on their own roots, so that it is necessary to provide winter feed.

The carrying capacity of the coastal prairies is probably on the whole about the same as that of the salt marshes, though they deteriorate from overgrazing, not because the soils become worn out, but through influx of weeds and sour grasses which gradually displace the better ones.

Farther down the coast, in Victoria, Calhoun, and Jackson counties, the three sedge grasses mentioned above constitute 40 per cent of the vegetation. Bearded mesquite (*Stipa leucotricha*) makes up fully 25 per cent, while honey dew (*Paspalum plicatulum*) amounts to 20 per cent. The other 15 per cent is made up as before of a great variety of forms, including knot grass, broad-leafed Bermuda (*Paspalum distichum*), wild barley (*Hordeum pusillum*), wild millets (*Chaetochloa*), switch grass, white grama, Colorado grass (*Panicum texanum*), and a score of others, all in great profusion of form, but no one species supplying any very large portion of the forage.

The grasses of the wooded bottoms are neither abundant nor nutritious, so that their grazing capacity seldom amounts to more than one-fourth as much as that of the open prairies. The dominant, and at the same time the most valuable, species is elm grass (*Panicum prostratum*). With this there occur Terrell grass (*Elymus virginicus*), wild timothy (*Phalaris angusta*), cotton-top (*Panicum lachnanthum*), and others. Here also in the dense shade occur numerous wild beans and what stockmen call a wild four-leaf clover (*Marsilia macropoda*), one of the fernworts, a relative of the Australian "Nardoo," which is also regarded as of some value as forage.

Between Rockport and the southern shore of Corpus Christi Bay the soil is black "hog-wallow" prairie extending to the beach, with no marsh intervening. Salt-water cord grass (*Spartina stricta*) replaces bunch salt grass to a considerable extent. It grows as well between high and low tide as farther back on the landward side of the marshes, and is here a rapid land-builder, continually advancing, forming little peninsulas which stretch out into the sea and cause shallows to form

where driftwood and sediment are caught. The shore line is thus encroaching upon the waters of the bays. If this grass could be utilized artificially in the same way, a broad beach could be rapidly formed along the entire coast wherever there are existing shallows.

THE CACTUS PLAINS.

The black land coastal prairies end a few miles below Corpus Christi, where the transition between the "hog-wallows" and the "sands" is quite sharply marked. The southern Buffalo grass (*Bulbilis*) is the most common prairie grass, producing in many places fully 75 per cent of the forage. Bermuda grass is abundant along the streams and on the borders of tanks and ponds. The bur-grass (*Cenchrus tribuloides*) (fig. 3) is very plentiful, and is considered valuable up to the time when the burs are ripe. After that it is a great pest. Were it not for the burs this would be one of the best of the wild grasses, because it is one of the earliest to commence growth in spring and is also quite hardy. Cattle relish the herbage, usually eating it down closely, even before the surrounding taller grasses are touched. Bur-grass is now widely distributed and probably occurs in every county in Texas and New Mexico where sheep are grazed, the burs being widely disseminated in the fleeces of these animals. It is probable that its objectionable qualities as a weed quite outweigh its value for early spring feed.

FIG. 3.—Bur-grass (*Cenchrus tribuloides*).

Dr. De Ryee, of Corpus Christi, states that the country between there and the Rio Grande was entirely open thirty years ago, sparsely grassed, and with only here and there a bunch of mesquite beans. Now all of the open spaces have been filled with thorn-thickets, often impenetrable to horsemen. In parts of Starr, Hidalgo, and Cameron counties the loose sands which comprise the surface soil are underlaid by fresh water at a depth of from 2 to 10 feet. The grasses here are mainly such as grow in bunches, like the needle grasses and bearded mesquites.

There is a low ridge or watershed parallel with the Rio Grande about 20 miles east of Laredo. From this ridge the land slopes both ways, forming a gradual descent to the east and a more abrupt one to

the south and west. The east slope consists of a broad border of black alluvial soil along the river, then a strip of sands 60 miles wide, and then black "hog-wallow" prairie on the northern edge of the sands. Each of these soil formations has its peculiar grasses. At San Diego, which is on the western border of the arable soil, the dominant species are seed mesquite (*Bouteloua texana*) (fig. 4) and two gramas, *B. trifida* and *B. bromoides*. The occurrence of the gramas as the dominant species seems always to mark the transition from arable to pasture lands. Proceeding toward Laredo on the line of the Mexican National Railroad, the soil changes abruptly from gray-black to brick-red, and soon becomes almost pure sand. On these sands, as on the sands of Cameron County, the vegetation is largely bunch grass. There is still an open strip about 35 miles wide near Hebronville, but it is only a question of a few years before the brush and cactus will have advanced from both directions to take complete possession of it.

FIG. 4.—Seed mesquite (*Boutelaua texana*).

The valley of the Rio Grande is arid, receiving only a small amount of rainfall, poorly distributed, throughout the year. The soil is shallow, and sterile because of an insufficient supply of moisture. The vegetation consists of dense chaparral, with close thickets of various kinds of cactus, and the grasses are few and scattering. There is almost no water back from the river, and the brackish or salty underground flow lies from 200 to 300 feet below the surface. The carrying capacity of the chaparral-covered valley lands is never more than 30 head to the square mile. Grasses exist so sparsely that the destruction of brush and cactus by fire is almost out of the question, and could only be accomplished by sacrificing the grass accumulation of several years. The only practicable method of improving the conditions would be the introduction of forage shrubs from similar arid regions abroad, the construction of reservoirs or tanks to catch and hold the storm waters which descend as torrential rains, and the irrigation of the narrow val-

ley. It is possible that the thornless Indian-fig cactus of Algiers and southern France could be introduced with profit into the Rio Grande Valley. A similar cactus is grown in the vicinity of Monterey, Mexico, and has been cultivated at Corpus Christi by Dr. William De Ryee and at Santa Gertrudes by Mr. R. J. Kleberg. However, this pear cactus is not frost-proof, like the native species. Dr. De Ryee states that the spines may be eliminated from the common species by pursuing the same course of treatment as that used in the production of the spineless form by the Mexican gardeners, who grow it for its superior fruit and not for its excellence as a forage plant. A young shoot or joint of the flattened stem taken before the spines are fully formed is set out in fertile soil. As soon as this has taken root and started to grow, a young cutting from the plant is treated in the same way, and so on, continuing for two or three seasons, always planting in rich and well-watered soil. By the third or fourth year the cactus will usually have lost all of its spines, so that there is nothing to prevent its being eaten by cattle. This Mexican cactus might be acclimated by the method of gradual transference each year a little farther north, and also by selection of the most hardy stocks; or, better, the same method of cultivation and improvement might be applied to cuttings of the superabundant Texan prickly pear with the view of securing an unarmed form of it for propagation in the arid portions of the State. The experiments would necessarily last through a long term of years, because the same care would be required in selecting hardy and drought-resistant spineless forms as in coaxing the plant to repress its spines. If the smooth form is transferred abruptly back to normal conditions of sterile soil and lack of moisture, the spines at once reappear, while both stem and fruit lose whatever points of excellence they may have acquired through cultivation. The experiment would have to be continued long enough for the acquired characters to become in some measure fixed. Such an improvement through cultivation would elevate the pear cactus to the rank of the cultivated plants. The rancher who wished to avail himself of it would have to grow the spineless forms on good rich soil, and sow the seed over the ranges at intervals of a few years. There would certainly be a return to the normal form in time, just as there is in the case of the carrot, or of the red pepper grown first on cultivated soils and then allowed to run wild, but if the spineless habit could become sufficiently fixed as a result of growth under improved environment the reappearance of sharp spines when the plant is grown on poor soil might be retarded several years. Such experiments ought to be undertaken, for if thornless cactus of some forage value could be grown in the place of the inedible wild varieties it would prove of immense pecuniary advantage to the stockmen of this portion of the State. A spineless form of the common prickly pear of India (*Opuntia dillenii*) is there used for forage, and it is reported that good silage has been made from a mixture of cactus and grass placed in the silo in alternating layers. A

spineless pear cactus also occurs in South Africa, and is there used as forage.

Proceeding northward from Laredo the character of the land remains much the same for 50 miles, improving very gradually until the valley of the Nueces is reached. From the Nueces to the Guadalupe the soils are mainly rich black or chocolate loams, well grassed with an abundance of species, the curly mesquite predominating on the uplands, and Bermuda along the streams. The carrying capacity is high, ranging from 55 to 70 head per square mile, and, while held to have decreased from one-fourth to two-fifths on account of overstocking during droughts, the quality is now considered to be steadily improving. The chief means of betterment of the forage conditions here is the cultivation of hay and coarse forage such as sorghum, Colorado grass, cowpeas, alfalfa, and milo maize. Stack silage can also be used to advantage with cotton-seed hulls and meal for winter feeding.

FIG. 5.—Rescue grass (*Bromus unioloides*).

THE MIDDLE PLAINS.

The region 100 miles west and 150 miles northwest from Bexar County is all broken country, with flinty limestone outcrops on lower slopes of the water sheds. The soils are patchy—black prairie loams on the backbone of the ridges, with gray, red, brown, chocolate, and black soils in the valleys and on the lower slopes. There are in parts of this region numerous and extensive gravel deposits of apparently lacustrine origin. Much of the section is quite mountainous. The rainfall is rather abundant, coming mostly during the spring and early summer months, but is not entirely limited to any one season, so that the conditions are excellent from the stockman's standpoint. This is a transition area as regards the grass flora. The striking grasses of the river valleys are those which thrive in the humid eastern portion of the State, including *Limnodea*, rescue grass (fig. 5), satin grasses (*Muhlenbergia*),

Uniola latifolia, *Melica mutica*, wild rye and Terrell grass. The grasses of the uplands are the same as those of the prairies. The needle grasses compose 25 per cent of the total; seed mesquite and the two curly mesquites each 10 per cent, and side-oats grama, feather sedge, switch grass, wild millet, windmill grass, and species of *Triodia*, *Eragrostis*, and *Sporobolus* together supplying the remainder.

THE GRANITE REGION.

In the mountainous granitic area of Burnet, Llano, and Gillespie counties there are fewer turf-forming grasses and fewer well-grassed pastures than in almost any other portion of the State. Bur grass is omnipresent, and the other species are in the main those of central Texas. A noticeable feature is the great abundance of leguminous plants. Vetches (*Vicia* and *Lathyrus*) and wild beans (*Phaseolus*) occur along every stream and in the scrub-oak copses. The buffalo peas (*Lupinus* and *Astragalus*) give color to the landscape in early spring, while in April the Texan pea (*Astragalus nuttallianus*) forms a thick growth over square miles of the granitic ridges. This area was originally more or less thickly covered with oak forest, and is now very brushy. The winter and spring pasturage is as good as anywhere in the State. The addition of good grasses to supplement the native legumes and supply summer and autumn feed would make this part of Texas the best grazing ground in the State, for there is plenty of water and good shelter at all seasons of the year. In times of drought the oak scrub is eaten by cattle and will keep them alive until the rains come. The mesquite beans are valuable at such times, as is also the mistletoe, which is parasitic on them. Mistletoe is said to be poisonous when fed to very young stock, and liable to cause abortion among cows, especially if eaten when other feed is scarce. The average carrying capacity of this mountainous area is about 40 or 50 head of cattle per square mile. The range could be improved by introducing upland alfalfa, Japan clover, Bokhara clover, and legumes adapted to rocky soils, and by devoting a larger acreage of the better valley lands to the cultivation of sorghum and Kafir corn or milo maize. In this and other portions of the State the unrestricted pasturing of hogs has been a potent factor in the destruction of the grasses. They not only disseminate seeds of the prickly pear more rapidly than would be the case were they kept within bounds, but they consume seeds, roots, and tubers of a variety of valuable plants to such an extent that many of the best are all but exterminated.

THE RED PRAIRIES.

To the northward of the middle plain and granitic area there lies a prairie region which slopes gently downward from the eastern edge of the Staked Plains, by a succession of steppes, to about the ninety-eighth meridian. This prairie region ranges from 1,200 to 3,000 feet in altitude and, while it is intercepted in the southern portion by a number of

low mountainous ridges lying between the rivers, the bulk of the lands are level or gently rolling.

The entire region lying north of the Colorado and Concho rivers is well grassed and watered and is not overrun to such an extent by the mesquite bean and prickly pear as are the ranges farther to the southward. The chief pest and the one which causes the greatest destruction of grasses is the prairie dog, which, according to stockmen, is rapidly increasing in numbers, so that in some places the carrying capacity has diminished fully 50 per cent within less than ten years from this cause alone. This portion of the State, together with the Staked Plains, was formerly the winter feeding ground of a large part of the great southern herd of buffalo, and it is the portion which benefited most during the ten years immediately succeeding the destruction of the buffalo. The rainfall at Abilene, which may be taken as a central point from east to west, averages about 27 inches per year, although there has been a variation of from 11 to 35 inches during a series of twenty-five years. The rainfall of the region as a whole is probably between 20 and 30 inches, placing it within the category of semiarid sections. During average years cereals and cotton may be successfully grown, but the whole area is liable to suffer from severe droughts in off years, during which no dependence can be placed upon any of the cultivated crops. Such semiarid countries, no matter where they exist, can best be utilized in pasturing live stock, and the live-stock interests will always be the most important ones, even though certain of the more fertile valleys are converted into farm lands. The carrying capacity of the land here was formerly equal to the best. It is estimated that in 1880 the average for this whole region could not have been much less than 100 head per square mile, while picked sections would carry 320 head. Now it has been reduced to between 40 and 50 head, a fall of fully 50 per cent in the producing value of the land in the course of less than twenty years.

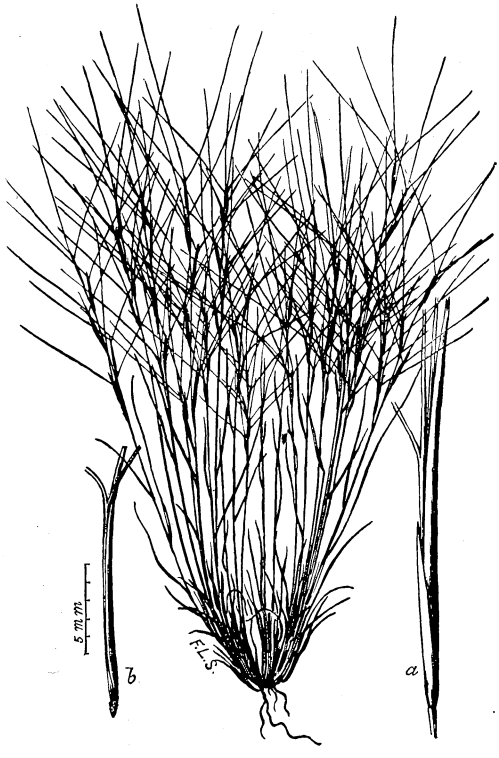

FIG. 6.—Needle grass (*Aristida fasciculata*).

The predominating grasses are the needle grasses (*Aristida fasciculata* and *A. coarctata*) which form fully 50 per cent of the entire grass vegetation, and more than that on the pastures which have been overgrazed. Stockmen consider the needle grass most nutritious and valuable, although many of the closely related species that occur in the Gulf States are there known as the much despised poverty grasses, held to be characteristic of the poorest land and all but worthless for pasturage. However, there is no doubt that here the needle grasses hold a position which could not be filled by anything else. They are the first to start growth in the spring, and after the sharp bearded seeds have fallen in autumn, cattle and sheep greatly relish the stems and leaves. The stalks remain green at the base long after the curly mesquite has become brown and dry. The bearded seeds undoubtedly cause some inconvenience to animals, especially to sheep. Losses among lambs are frequently reported through the needle-grass seeds piercing their skins or perforating their intestines. But aside from such trifling losses the fact remains that there is no grass which will spread so rapidly if only given a chance to ripen its seeds, as the three long beards attached to each enable it to be readily blown about by the winds. When the sharp point catches in loose earth the drying and wetting of the beards causes the seed to bore into the soil, burying it deep enough to insure germination. Wherever there is a ridge or mound of bare earth, or a furrow, the needle-grass seedlings grow abundantly.

FIG. 7.—Black grama (*Hilaria mutica*).

The black grama (*Hilaria mutica*) (fig. 7) occurs quite abundantly in some of the valley pastures. It was formerly much more plentiful. It is one of the best of the winter grasses. Cattle do not seem to relish it in summer as long as there are tenderer annual grasses in abundance. Its stems and lower leaves remain green long after the first frost, and the whole plant cures on its own roots, forming first-class natural hay which is much relished in winter. Black grama hay was highly valued in the early days, but it is hardly ever found now sufficiently abundant to mow. The river valleys of this region are the

original home of the Colorado grass or Texan millet (*Panicum texanum*), a leafy annual, whose merits as a hay grass have led to its becoming widely cultivated. Everlasting grass (*Eriochloa annulata*) and an Indian millet (*Panicum ciliatissimum*) also grow along the river bottoms and supply leafy herbage that is greatly relished by cattle.

The curly mesquite grasses (*Hilaria cenchroides* (fig. 8) and *Bulbilis dactyloides*) are omnipresent. They monopolize a large share of the range, supplying sometimes as much as 80 per cent of all the vegetation. Their long, creeping runners and short, crisp leaves form a matted sward that improves under an amount of abuse and hard usage that would kill out less hardy grasses.

FIG. 8.—Curly mesquite (*Hilaria cenchroides*).

The blue grama (*Bouteloua oligostachya*) and side-oats grama (*B. curtipendula*) are abundant, forming a valuable factor of the range pasturage. The chief needs of the Red Prairie region are better winter and early spring forage. The former may be supplied by putting up fodder, hay, or stack silage.

To supply spring grazing the tallow weed (*Actinella linearifolia*) should be cultivated. This plant belongs to the tansy family. It is widely distributed in Texas and the Southwest, clothing the prairies with its bright yellow flowers and strap-shaped leaves long before any of the grasses have commenced to grow. Cattle and sheep are equally fond of it and its feeding value may be judged from the common name which it bears among stockmen. It is said that there is no wild forage plant which will put so much fat on an animal in so short a time. The tallow weed is truly a blessing to stock and stockmen, whose only criticism in regard to it is that there is not enough of it.

THE STAKED PLAINS.

The Llano Estacado or Staked Plains consist of an oblong plateau having a greatest width of about 180 miles from east to west, with a length of about 225 miles from north to south. This tableland lies approxi-

mately between the one hundred and first and one hundred and fourth degrees of longitude and between the thirty-second and thirty-fifth parallels of latitude. The altitude ranges from 3,500 to 4,500 feet, being greatest along the western border in New Mexico, thence sloping uniformly toward the southeast. The plains proper contain about 35,000 square miles in Texas and New Mexico. The surface is a succession of gently rolling hills with long ridges and valleys, the ascents being so gradual that they are hardly noticeable. The soils are mainly chocolate or reddish loams. Well water can be obtained almost anywhere within moderate depths from the surface. The northwestern border of the Staked Plains is more or less channeled with deep "arroyos" or canyons. The upper valleys of the Salt and South Forks of the Brazos River and of the Red River are very wide, showing that they formerly carried much more water than during recent years. The southern half is more sandy than the northern, with bare sand hills in Cochran, Terry, Yoakum, Gaines, and Anderson counties, Tex., and in eastern Chaves and Eddy counties, N. Mex. There are numerous brackish or saline lakes at about the geographical center of the plains, occurring through Gaines, Lynn, Terry, Hockley, Lamb, and Bailey counties, Tex. The entire region, with the possible exception of the sand hills, is admirably adapted for stock raising. It is well grassed with an abundance of species, and, while not watered by flowing streams as are the lower prairies bordering the Plains on either side, yet the configuration of the underlying strata is such that, as previously stated, an abundance of sweet water for stock purposes can be secured almost anywhere. The geological formation indicates that this entire region was formerly the bed of a great inland lake, and since its elevation in recent geologic times it has lost less by erosion and its character has undergone less change than the better-drained and better-watered prairies to the eastward. The soils are exceedingly rich, so that in good seasons or wherever water is near enough to the surface to be cheaply and abundantly raised by means of windmills for use in irrigation large crops of cereals, vegetables, fruits, and forage plants can be grown; but in ordinary seasons, or in the absence of water within moderate distance below the surface, the amount of moisture retained by the surface soils is not sufficient for the purposes of agriculture. The native grasses grow luxuriantly. The species are mostly identical with those which thrive on the high plains of western Kansas and Nebraska, consisting of wheat grass (*Agropyron spicatum*), little blue stem (*Andropogon scoparius*), side oats grama (*Bouteloua curtipendula*), blue grama (*B. oligostachya*), and buffalo grass (*Bulbilis dactyloides*). These species supply the larger part of the grazing, especially in the northern portion of the Plains. On the sandy lands in the southern half of the Plains, feather sedge (*Andropogon saccharoides*) coming up from the prairies of southern Texas displaces the little blue stem, and a number of other grasses identical with those of the Pecos Valley are abundant, including the

two species of black grama (*Bouteloua eriopoda* and *Hilaria mutica*), and the southwestern species of *Sporobolus*, *Muhlenbergia*, *Aristida*, and *Panicum*. In the southern portion of the Plains the number of species of gramas (*Bouteloua*) increases and they, together with *Hilaria mutica*, form the bulk of the grass vegetation. The gramas of this region are *Bouteloua polystachya*, *B. oligostachya*, *B. eriopoda*, *B. vestita*, *B. curtipendula*, *B. hirsuta*, and *B. ramosa*. The number of species of *Sporobolus* also increases, and *Aristida arizonica*, *A. micrantha*, and *A. bromoides* take the place of the common dog-town needle grass (*A. fasciculata*) of the prairies. Because of the absence of running streams and surface water for stock purposes, the Staked Plains have been less severely overgrazed than the lower plains and prairies surrounding them. Now, however, since it is found that water is fairly abundant and within reach of windmill power, the land is being rapidly stocked. The grazing capacity is higher than in many other portions of the range country which have been stocked for a much longer period.

The best means of improving the range on the Staked Plains are, first, to provide stock water at intervals not greater than 4 or 5 miles apart, so that cattle will not have to travel more than 2½ miles in any direction; second, to provide winter shelter or protection from the storms which have uninterrupted sweep over this table-land during the winter months; and, third, to provide sufficient hay or coarse fodder to feed the cattle during the heavy storms.

On almost every ranch there will be found old lake beds, sinks, or shallow valleys where the soil contains enough moisture within reach of the surface to be readily available to the roots of cultivated plants. On such lands sorghum, Kafir corn, milo maize, the millets, and in especially favored localities alfalfa, and perhaps the soy bean, can be grown, and enough hay saved to provide against periods of shortage either during winter or in time of drought.

The carrying capacity of the Plains ranges from 40 to 64 head per square mile. Assuming the preposterously low figure of 30 head per square mile as the average annual grazing capacity, more than 1,000,000 head of cattle can be pastured. The capacity for improvement here is as great as in any other part of the Southwest, so that with a judicious use of the natural resources the number can easily be doubled or trebled within the next ten years.

THE PECOS VALLEY.

The Pecos Valley in New Mexico, extending almost due north and south, from about the thirty-fourth parallel to the southern border of the State, was formerly very well grassed. All of the living tributaries of the Pecos below Fort Sumner enter it from the west. For fully 200 miles below this point there is no stream of any importance which drains into the Pecos River from the direction of the Staked Plains. The lands in the valley are exceptionally well located for culti-

vation under irrigation, and several hundred thousand acres are under ditch, while it is estimated that 1,000,000 acres are capable of being thus improved.

The principal grasses in the Pecos Valley are salt grass (*Distichlis spicata*), in the alkali spots along the lowest portion of the valley, saccaton (*Sporobolus wrightii*), wild rye (*Elymus canadensis*), western wheat grass (*Agropyron spicatum*), and alkali grass (*Sporobolus airoides*). Back from the immediate river valley on the richer bottom lands blue grama (*Bouteloua oligostachya*) grows sometimes almost pure, or intermingled with woolly foot (*B. eriopoda*) (fig. 9), and black grama (*Hilaria mutica*). In the northern portion of the valley the grasses are practically identical with those of the northern half of the Staked Plains. The gramas are the most abundant, supplying fully 80 per cent of the entire forage of the ranges, the balance being furnished by perhaps twenty-five or thirty species. The carrying capacity of the ranges in the Pecos Valley varies more widely than in any region in Texas, because of the unrestricted grazing of cattle and sheep on the public lands. In dry years there are often areas where 60 acres would hardly support 1 cow, while in good seasons the same lands if undergrazed in the droughty seasons will support from 40 to 60 head to the square mile.

FIG. 9.—Woolly-foot (*Bouteloua eriopoda*).

RELATION OF LAND LAWS TO RANGE IMPROVEMENT.

The range lands in New Mexico, with the exception of frontages along streams, sections, or quarter sections containing springs and land which may be artificially watered by shallow artesian wells, are still owned by the Federal Government, 69 per cent of the territory being Government land, and 58 per cent is classed as grazing lands, amounting to 45,000,000 acres. Texas having been independent pre-

vious to its annexation to the United States contains no public land other than that belonging to the State, and the use of pasture lands within its borders is regulated entirely by State land laws. With the exception of California it is the only one of the Western States where the ownership of the ranges does not lie entirely in the National Government. The only way in which the nonmineral lands can be filed upon is either under the right of preemption, under timber claim laws, desert land laws, or those relating to irrigated lands. There is no system for disposing of areas unsuited for agriculture other than under some one of these laws, and the result is that the grazing lands are held as commons open to any stockman who can run his cattle upon them. *There is no law which recognizes the existence of pasture lands or in any way provides for their management and disposal.*

The problem of range improvement in New Mexico, and in every one of the Western States and Territories where there are still large bodies of Government lands, is not wholly the introduction of new and better grasses nor the cultivation of better forage crops. The first and foremost necessity, if the extravagant waste of the public domain is to be prevented, is to devise some system by which grazing lands can be placed in a class separate from agricultural lands, and under which property rights in lands now free to everyone may be assumed by individual stockmen.* It has been the experience in all pastoral countries that proper care and conservation of the forage resources can only be secured and will only be practiced where the tenure of the land is sure. The necessary fixity of tenure might be legally provided for by long-term leases directly from the General Government at a nominal rental per acre.

As it is at present, the value of the grazing on the public lands depends almost entirely upon such matters as seasonal rainfall and accessibility. The winter of 1896–97 was accompanied by exceptionally heavy rainfall over almost the entire southern and eastern portion of New Mexico. This combined with the extraordinary shortage of cattle on the ranges permitted the rapid development of the range grasses, so that during 1897–98 the supply of feed was unusually large; and, whereas the southern portion of the valley not having received any more than the normal precipitation, would not carry in the spring of 1897 more than 10 to 20 head per square mile, the upper portion of the valley at the same period was covered with grasses and would have carried at least 50 head to the mile on almost any portion of it.

Aside from the effect of overgrazing on the lands themselves and on the natural grasses with which they are covered, it is well to note that millions of cattle and sheep are grazed on free lands in every Western State and Territory. These lands contribute no taxes for the support of the State governments. The cattle when marketed may be sold at a much lower figure than those raised on taxed lands owned by the stock

* F. V. Coville, in Forum, September, 1898.

grower and still make a profit. It is not fair to the people who are compelled to bear the expenses of local government for large untaxed areas, nor on the other hand to the cattle men and woolgrowers of the East whose products come into competition with those grown almost without expense on free Government lands. The policy which governed the settlement of the prairie States might well be modified to meet the demands of the stock raisers, especially as a very large percentage of the Government land now remaining is not agricultural and can not be made so by irrigation. The best policy is that which will the best promote permanent settlement. It is necessary that timely action shall be taken to open up the public lands for settlement in tracts extensive enough to encourage men to build ranches and make permanent improvements upon them. The continued existence of great bodies of free lands covered with free grass is demoralizing to all those who take advantage of the opportunities presented thereby. As suggested above, probably the most feasible plan would be to provide for long-term leases of the public lands for grazing purposes.

BENEFITS OF IMPROVING THE RANGES.

The number of cattle owned in the State of Texas on January 1, 1899, was estimated at 4,533,897 head, valued at $76,665,937. At the same time there were 2,513,917 head of sheep, valued at $4,448,039, and 1,137,015 horses, valued at $20,088,788. The total value of sheep, horses, and cattle, exclusive of milch cows, at that date was $101,202,764. Nearly all of the sheep and a majority of the cattle and horses were grazed or fed within the territory included in this report. It can be safely taken as correct that 75 per cent of the 8,215,000 of live stock of these three classes is pastured on an area of less than 200,000 square miles, or, in round numbers, about six and one-fifth million head of stock are pastured on one hundred and thirty million acres of land. Now, if by any of the methods which have been suggested here, or by any treatment which may be devised, the carrying capacity of these arid land pastures could be improved and increased even to the extent of 25 per cent, it would mean an increase in taxable values of the State of at least $25,000,000. It is the opinion of a majority of stockmen who have raised cattle and sheep in Texas and New Mexico during the last twenty-five years that there has been a marked decrease in the amount and value of the natural forage, resulting in a proportional decrease in the number of cattle grazed. As has been stated above, an average of decrease taken from estimates made by 300 stock owners in Texas in 1897 was about 40 per cent. There is no doubt whatever in the minds of men who have studied the capabilities of the Texas soils that the lands themselves are nearly as fertile as they ever were. In fact, it is a general law that the lands in exclusively pastoral countries are continually improving in fertility as opposed to lands devoted to the cultivation of cereal and staple crops, because little of the essen-

tial mineral ingredients are removed, while the organic matter in the soils is steadily increased. Forty per cent of increase over present capacities is not an improbable one, and there are many of the more sanguine stockmen who believe that the grazing capacity of large areas can be increased 100 per cent by undertaking proper methods of treatment. Such improvement will undoubtedly be slow, but the results will justify the effort.

INDEX.